NPR 8705.5
Probabilistic Risk Assessment (PRA) Procedures for NASA Programs and Projects

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Objectives

- Supports the implementation of structured Risk Management (RM) as stated in NPR 8700.1, *NASA Policy for Safety and Mission Success*

- Provides both qualitative and quantitative results regarding weaknesses and vulnerabilities in systems that can adversely impact safety, performance, and mission success.

- Provides insights into viable RM strategies by supporting optimal decisions with respect to the expenditure of resources.

Purpose of NPR 8705.5

- Provides basic requirements for performing a probabilistic risk assessment (PRA) for a NASA program or project.
- A companion document is the Probabilistic Risk Assessment Procedures Guide for NASA Managers and Practitioners (http://www.hq.nasa.gov/office/codeq/doctree/praguide.pdf)
- Addresses technical and safety risk and does not address programmatic risk involving consideration of cost and schedule.

Applicability

- Programs/projects that provide aerospace products or capabilities; i.e., space and aeronautical systems, flight and ground systems, technology demonstration / validation, and operations
- Not required for other projects; i.e., research, training, or education
- Applicability to programs/projects in progress will be made on a case-by-case basis and approved by the Governing Program Management Committee

Level of the PRA

The importance and scope of the project or program being assessed is used to identify the extent of the risk assessment application.

- **Potential affects on the public, crew, workers, strategic importance, value and schedule**

- **Full-scope, Limited-scope and Simplified**

When to USE PRA: Criteria for Selecting the Scope of a Probabilistic Risk Assessment (PRA)

CONSEQUENCE CATEGORY	CRITERIA / SPECIFICS		NASA PROGRAM/PROJECT (Classes and/or Examples)	PRA SCOPE
Human Safety and Health	Public Safety	Planetary Protection Program Requirement	Mars Sample Return Missions	**F**
		White House Approval (PD/NSC-25)	Nuclear Payloads (e.g., Cassini, Ulysses, Mars 2003)	**F**
		Space Missions with Flight Termination Systems	Launch Vehicles	**F**
	Human Space Flight		International Space Station	**F**
			Space Shuttle	**F**
			Human Space Experiments	**F**
			Project Constellation	**F**
Mission Success (for non-human rated missions)	High Strategic Importance / High Value Strategic Property / High Cost Projects		Mars Programs	**F**
	High Schedule Criticality		Launch Window (e.g., planetary missions)	**F**
	All Other Missions		Earth Science Missions(e.g., EOS, QUICKSCAT, specific payloads)	**L/S**
			Space Science Missions (e.g., SIM, HESSI, specific payloads)	**L/S**
			Technology Demonstration / Validation (e.g., EO-1, Deep Space 1)	**L/S**
			Medium to Low Cost Projects	**L/S**

***Key:**

F – Full scope PRA.

L/S – Limited-scope or simplified PRA should be performed or altogether waived, at the direction of the program/project.

Full Scope PRA

A Full-scope PRA supports risk management for projects involving complex systems in high-stakes programmatic contexts:

- **Addresses all applicable scenarios and end states that lead to failure to meet safety and mission objectives.**
- **Includes a complete uncertainty analysis to provide the overall degree of uncertainty in results and an understanding of the critical sources of uncertainty.**

Limited-Scope PRA

Limited-Scope PRA focuses on specific mission-related end states of interest, instead of all applicable end states

- **The scope is defined so that the results can provide specific answers to pre-identified mission-critical safety concerns**

- **Sources of uncertainties that have a strong effect on the results and their insights are identified and quantified**

Simplified PRA

Simplified PRA identifies and quantifies major mission risk contributors (to all end states of interest)

- **Generally applies to systems of lesser technological complexity or systems having less available design data.**
- **Reduced set of scenarios or simplified scenarios designed to capture essential, top level, mission risk contributors.**
- **Sources of uncertainties that have major effects on results are identified and, in cases where they affect management decisions, shall be quantified**

Documenting PRA Decisions

- **Program/Project Manager documents PRA level and basis in risk management plan**
- **Program/Project Manager brief GPMC during formulation phase**
- **Disputes concerning PRA decisions and level shall be elevated to the next level of PMC**

Implementation Responsibilities

NASA shall, through prudent hiring, professional development, and mentoring, increase and maintain its capability to conduct, understand, and use PRA in support of a program/project life cycle

Implementation Responsibilities

- **Office of Safety and Mission Assurance will maintain best available PRA methods, practices, applications, software, and standards:**
  - **Develop, coordinate, publish, disseminate, explain, interpret, and maintain NASA PRA policy, procedures, criteria and guidelines and assure implementation**
  - **Provide corporate and functional leadership in PRA related information, applications and methodology**
  - **Organize and coordinate peer reviews of PRAs**

Implementation Responsibilities

Associate Administrators and Mission Directorates are responsible for assuring that RM policies, plans, techniques, procedures, and standards are implemented:

- **Appropriate resources available for the PRA**
- **Technical quality throughout PRA efforts**
- **PRA results communicated to appropriate personnel**
- **PRA awareness and training for managers and practitioners**
- **PRA requirements are implemented on contracts**

Implementation Responsibilities

Center Directors shall:

- **Ensure that their organizations acquire and maintain PRA expertise necessary to support Center-based programs/projects**
- **Assist Center-based programs/projects in conducting required PRAs; i.e., provide required resources, training, tools, technical advice, or assistance in obtaining competent support services**

Implementation Responsibilities

- **Program/Project Managers:**
  - **Conduct and use PRA to support risk management decisions**
  - **Document PRA plans in the risk management plan**
  - **Brief the GPMC on PRA decisions and rationale during the formulation phase of the program or project**
  - **Maintain and safeguard PRA records (NPR 1441.1, NASA Record Retention Schedule)**
  - **Clearly communicate PRA results and insights**
  - **Update management plans to reflect insights from PRA**
  - **Consider modifying the project through design, operation, and maintenance upgrades if the residual risk is deemed unacceptable**

PRA Process

- **PRA characterizes:**
  (1) What can go wrong? (2) How likely is it? (3) What are the consequences?

- **A typical scenario-based PRA involves:**
  - **Definition of objective***
  - **System familiarization**
  - **Identification of initiating events***
  - **Scenario modeling***
  - **Failure modeling***
  - **Quantification***
  - **Uncertainty analysis***
  - **Sensitivity analysis**
  - **Importance ranking**
  - **Data analysis***

* - Required Elements

PRA Implementation

- Scope of the PRA is commensurate with objectives, complexity of the system, and severity of the consequences
- Use consistent defined terminology (with that used in the program/project)
- Identifies the elements of risk (initiators, hazards, scenarios, probabilities, consequences and uncertainties
- Uses analytical method and techniques consistent with the systems being analyzed
- Uses existing generic and specific data
- Has periodic in process reviews

PRA Team

- Multi-disciplinary team representing key functional elements (design, operation, safety, maintenance) and organizations
- Team has training and experience in the development of a PRA and the application of PRA methods, techniques and models.
- Considers impacts of inter- and intra-project or mission dependencies
- Uses insights from crew, ground personnel, and workers to develop an objective "un-biased" model.

PRA Development

- A PRA expert shall serve as the PRA Technical Authority on programs/projects, with technical PRA decision-making authority
  - Selection of the PRA Technical Authority shall be made with guidance from the Center SMA or HQ SMA organization
- A PRA shall follow quality assurance principles and practices that are analogous to those in other engineering fields and practices
  - Suitable team
  - Proven methods and computer codes
  - Documented assumptions and ground rules
  - Use of appropriate engineering and reliability data
  - Internal Review
  - Communication

Independent Peer Reviews

- **An independent peer review shall be conducted for all full-scope PRA**
  - **Concentrate on the appropriateness of methods, information, sources, judgments, and assumptions as well as the application and results**
  - **A participatory peer review that proceeds in parallel with the PRA should be considered**

PRA Application

- A PRA shall be comprehensive, balanced, and tailored
  - Considers complete environment and all factor that pertain to system being assessed
  - Scope considers issues of safety, operation and mission assurance, is commensurate to the level of risk and is timely for risk management decisions
  - Level of detail is proportional to PRA scope and objectives, and system complexity and hazards.
- PRA used as a “Living Tool” to facility continuous risk management
- A PRA shall consider all life cycle phases
  - Design
  - Operation
  - Upgrade
  - End-of-life/Decommissioning